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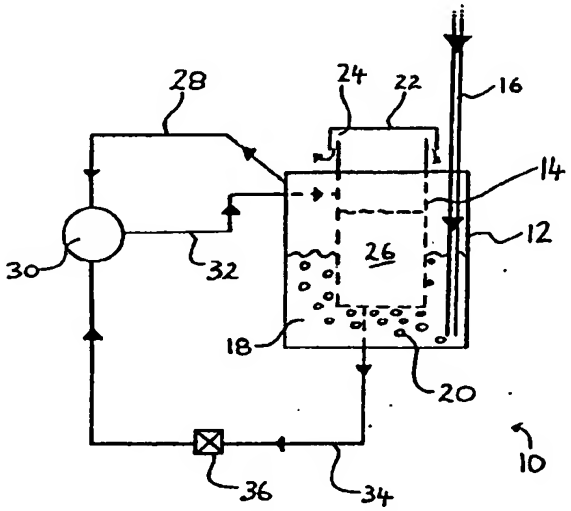
(54) Title: COOLING APPARATUS FOR RECIRCULATING VACUUM PUMP COMPRESSANT



(57) Abstract

A cooling apparatus (10) for cooling the compressant (26) in a liquid ring vacuum pump (30) comprises a closed liquid reservoir (12) located upstream of the suction line (28) to the pump (30) and a separator tank (14) containing a volume of compressant (26) located downstream of the pump (30) on the discharge line (32). The separator tank (14) has at least a part thereof in contact with the liquid (18) in the reservoir (12), and a recirculation line (34) extends from the separator tank (14) to the pump (30) to recirculate compressant (26), whereby heat from the separator tank (14) is transferred to the liquid (18) in the reservoir (12). Additionally, the incoming suction line (16) feeds into the liquid (18) in the liquid reservoir (12) whereby more heat and a portion of any particulate matter in the suction stream to the pump (30) is removed.

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TITLE

Cooling Apparatus for recirculating vacuum pump compressant.

DESCRIPTION

The present invention relates to a cooling apparatus for circulating vacuum pump compressant.

FIELD OF THE INVENTION

At present, in applications where a vacuum pump is used and there is some chance of particulate matter entering the pump a liquid-ring pump is most suitable. This is due to the liquid compressant located therein cushioning the impact of the incoming matter.

The liquid-ring pumps can operate under conditions wherein there is either self-contained compressant located within the pump, recirculation of compressant through the pump or simply a single-passage of compressant through the pump.

In applications where it is necessary to operate the pump for extended periods the self-contained pumps are not suitable as the compressant becomes too hot and decreases the efficiency of the pump. Also, there are many in use situations in which there is not a readily available supply of compressant making the single-passage pumps inadequate. A further factor that should be considered is the potential cost of compressant.

Accordingly, the most suitable liquid-ring pump for many applications is one in which the compressant is wholly or partially recirculated through the pump.

At the moment, a heat exchanger external to the pump is required to accept heat from the recirculating compressant

that is generated by the conversion of mechanical energy into heat of compression. The heat exchanger usually requires coolant to be pumped in and out involving a further item in addition to the pump and a recirculation or separator tank for the compressant. Alternatively, heat may simply be allowed to dissipate from the pump and separator tank. Both effects are undesirable and lead to inefficiency in the size and the pumping capacity of the pump.

For example, a liquid ring pump having a 3200 cubic metre capacity at 10°C has only a 1280 cubic metre capacity at 50°C.

The present invention has particular relevance to the operation of suction cleaning systems of the type comprising an air suction pump, a relatively coarse filter or settling tank located in a suction line upstream of the pump and a separator in a discharge line downstream of the pump wherein the pump is a vacuum pump. If a vacuum pump of the gear or lobe type is used they are susceptible to damage from particles of grit or dirt. As such, a liquid-ring pump is best suited to these conditions. Suction cleaning systems are often truck or trailer mounted. To enhance their portability a recirculation or separator for pump compressant is generally housed on board. Because of obvious size restrictions this tank has a limited volume. As a result, the compressant may potentially heat very quickly when the pump is operating and should be changed regularly. However, increasing the size of this separator tank restricts the size of the

remainder of the cleaning system and also increases the weight. Both effects are undesirable.

In addition, the heating of compressant also poses a problem when the liquid-ring pump is used as a compressor. Cooling of the compressant in this application will maintain the efficiency of the pump and magnitude of compression attained.

SUMMARY OF THE INVENTION

The present invention provides a cooling apparatus for recirculating vacuum pump compressant that allows the efficient cooling of the recirculating compressant through use of the air being pumped and a liquid reservoir.

In accordance with one aspect of the present invention there is provided a cooling apparatus for recirculating vacuum pump compressant comprising a liquid reservoir located upstream of an air-suction pump in a suction line and a separator tank containing a volume of compressant located downstream of the air-suction pump in a discharge line, the separator tank having at least part thereof in contact with the liquid reservoir and a recirculation line extending from the separator tank to the pump to recirculate compressant whereby heat from the separator may be transferred to the liquid reservoir.

Preferably, the suction line feeds into the liquid reservoir in such a manner that incoming air at least disturbs the liquid therein.

In accordance with a further aspect of the present invention, there is provided a suction cleaning system comprising an air suction pump, a liquid reservoir located

in a suction line upstream of the pump, a coarse filter or settling tank further upstream in the suction line, a separator tank containing a volume of compressant located in a discharge line downstream of the pump and being at least partially in contact with the liquid reservoir, and a recirculation line extending from the separator tank to the pump to recirculate compressant whereby heat may be transferred from the separator tank to the liquid reservoir.

Preferably, the liquid in the liquid reservoir is in intimate contact with at least a portion of the tank.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention will now be described, by way of example only, with reference to the accompanying drawings, in which:-

Figure 1 is a schematic representation of a cooling apparatus for recirculating vacuum pump compressant in accordance with the present invention;

Figure 2 is a schematic representation of the cooling apparatus of Figure 1 incorporating an extension to the separator tank; and

Figure 3 is a schematic representation of a suction cleaning system incorporating the cooling apparatus of Figure 1.

DESCRIPTION OF THE INVENTION

In Figure 1 there is shown a cooling apparatus 10 comprising a liquid reservoir 12 and a separator tank 14. A suction line 16 extends from an area upstream to which suction is being applied to the liquid reservoir 12. The

liquid reservoir 12 houses a volume of liquid 18. The suction line 16 introduces air and any contaminants contained therein into the liquid 18 in the reservoir 12 creating bubbles 20.

The separator tank 14 has a lid 22 and an open vent 24. A volume of compressant 26 is contained within the separator tank 14. The separator tank 14 is contained within the reservoir 12 and is in contact with the liquid 18 therein. A suction line 28 leads from a point in the reservoir 12 above the liquid 18 to a vacuum pump 30. The pump 30 has a discharge line 32 communicating with the separator tank 14. The discharge line 32 enters the separator tank 14 at a point above the level of compressant 26 as shown in Figure 1.

A recirculation line 34 communicates between the separator tank 14 and the pump 30. The recirculation line 34 allows passage of the compressant 26 from the separator tank 14 to the pump 30. A compressant feed pump 36 is provided in the recirculation line 34.

In Figure 2 there is shown a cooling apparatus 50 substantially similar to the cooling apparatus 10 and like numerals denote like parts.

The reservoir 12 has provided therein a ball-float valve 52 positioned so as close to the suction line 28 if the level of liquid 18 increases excessively. In addition, the suction line 28 has provided therein both an on-off valve 54 and a non-return valve 56. The non-return valve 56 is located down-stream of the standard valve 54.

A bypass line 58 joins the suction line 28 downstream of

the non-return valve 56. The bypass line 58 has provided therein an on-off valve 60.

The discharge line 32 has provided therein a radiator 62 with an associated fan 64 upstream of the separator tank 14.

The separator tank 14 further comprises a heat transfer element 66 located before the recirculation line 34. The element 66 is fed compressant 26 through a feed line 68. The feed line 68 has provided therein the compressant feed pump 36.

The bulk of the separator tank 14 is therefore located in a position remote to the reservoir 12 but has an extension thereof, the heat transfer element 66 located within the reservoir 12.

The heat transfer element 66 comprises a number of coils 70 preferably positioned along the level of the liquid 18 in the reservoir 12 as shown in Figure 2.

The separator tank 14 also has provided extending therefrom below the level of compressant 26 a flushing line 72 in which is located an on-off valve 74. The flushing line 72 projects into and terminates in the reservoir 12 at a point above the level of liquid 18. The portion of the flushing line 72 within the reservoir 12 has provided therein a plurality of apertures 76.

In Figure 3 there is shown a suction cleaning system 100 incorporating a cooling apparatus 102 substantially similar to cooling apparatus 10 and cooling apparatus 50 and like numerals denote like parts.

The bypass line 58 extends from the suction line 28 to a

settling or holding tank 104. The holding tank 104 has provided thereon a suction inlet line 106. The suction line 16 extends upstream from the reservoir 12 to the holding tank 104.

The holding tank 104 has a collection of large sized matter 108 that has settled therein by gravity after entering through the suction inlet line 106.

An on-off valve 110 is provided in the suction inlet line 106. It should also be noted that valve 74 of cooling apparatus 50 is located at the base of the separator 14 in cooling apparatus 102. They are equivalent in that they both provide direct access between the separator 14 and the reservoir 12.

In use, with reference to Figure 1 the pump 30 creates a suction force through the suction line 28. This suction force is transferred to the reservoir 12 causing air and any contaminants contained therein to be drawn into the liquid 18 through the inlet line 16.

The air being drawn into the liquid 18 creates bubbles 20 in the liquid 18. A proportion of any contamination in the air may be removed therefrom at this stage and remain in the liquid 18. Any remaining contaminant is very fine particulate matter and may be evacuated from the reservoir 12 through the suction line 28 where it is introduced into the pump 30.

The pump 30 is a liquid ring pump having a vane rotor eccentrically mounted within a casing. The casing is partially filled with compressant 26 which, when the rotor is driven, forms an annular layer between the casing and

the tips of the vanes of the rotor thereby forming a seal. The seal is achieved between the vanes and the casing without the vanes having to contact the casing.

The mix of air and fine particulate matter enter the pump 30 from the suction line 28 where the fine matter does not inhibit operation of the pump 30.

A mixture of air, any fine matter present and droplets of compressant 26 are discharged from the pump 30 through the discharge line 32 to the separator tank 14.

In the separator tank 14 the fine matter will settle at the bottom thereof whereas the air may be exhausted through the vent 24 to atmosphere. The droplets of compressant 26 fall to join the body of compressant 26 in the separator tank 14. The compressant 26 in the separator tank 14 is recirculated to the pump 30 through the recirculation line 34 aided by the feed pump 36.

As there is full recovery of compressant 26 used as a seal in the pump 30 the temperature thereof will rise. This can decrease the efficiency and efficacy of the pump 30. The contact between the separator tank 14 and the liquid 18 of the reservoir 12 serves to dissipate heat.

Heat from the compressant 26 is transferred to the liquid 18. The rapid passage of the bubbles 20 enhances the cooling of the separator tank 14 and the compressant 26 therein. In turn, heat may be dissipated from the liquid reservoir 12 to its surroundings, preferably to atmosphere. This dissipation of heat may be aided by construction of the reservoir 12 from materials encouraging heat transfer and the possible addition of a "heat sink"

arrangement thereto. Further, the separator tank 14 may have provided thereon a "heat sink" arrangement, such as a number of vanes, also.

It is envisaged that additional compressant 26 may need to be added to the separator tank 14 either due to evaporation or if the system is a partial recovery system.

The liquid 18 in the reservoir may simply be water, another coolant, or a combination thereof.

With reference to cooling apparatus 50 there are a number of additional characteristics to be noted, as is best seen in Figure 2.

During normal operation valve 60 and 74 are closed. As before, the suction line 28 transfers the suction from the pump 30 to the reservoir 12 and so on upstream to the suction line 16.

The mixture of air, any fine particulate matter present and droplets of compressant 26 discharged from the pump 30 pass through the discharge line 32 to the radiator 62 and fan 64. At this stage an amount of heat is released from the compressant 26 before entering the separator tank 14.

The compressant 26 in the separator tank 14 is then recirculated to the pump 30 through the feed line 68 aided by the feed pump 36. In turn, the compressant 26 passes through the heat transfer element 66 and coils 70 before entering the recirculation line 34 and finally re-entering the pump 30. A considerable amount of heat is transferred from the compressant 26 in the coils 70 to the liquid 18.

The suction cleaning system 100 and cooling apparatus 102 is substantially similar to that of cooling apparatus 10

and cooling apparatus 50. In effect, the cooling apparatus 50 and 102 can both be used in a suction cleaning system of the type described and the operation thereof will be apparent to the skilled addressee.

In use, the pump 30 creates a suction force through suction line 28 as described previously but with reference to Figure 3. During normal operation valves 54,56 and 110 are open whereas valves 60 and 74 are closed. The suction line 28 transfers the suction force to the reservoir 12. Air bubbles through the liquid 18 in the reservoir 12 from the suction line 16 running from the holding tank 104. In turn, the suction force is transferred from the holding tank 104 to the suction inlet line 106.

Large matter entering the holding tank 104 will generally fall under gravity to form the collection of matter 108. Smaller matter entering the holding tank 104 will exit through the suction line 16.

Air containing the smaller matter is bubbled through the liquid 18 where much of it is removed from the air. Any remaining matter is very fine particulate matter and may be evacuated from the filter tank through the suction line 28. The suction line 28 leads this mixture to the pump 30. The mix of air and fine particulate matter enter the pump 30 from the suction line 28 where the fine matter does not inhibit operation fo the pump 30. A mixture of air, fine matter and droplets of compressant are discharged from the pump 30 through the discharge line 32 to the separator tank 14.

From the separator tank 14 the fine matter will settle at

the bottom thereon whereas the air may be exhausted through the vent 24 to atmosphere.

Compressant 26 from the separator tank 14 is returned to the pump 30 through the recirculation line 34 aided by the feed pump 36.

If it is desired to clean the system of deposits valves 54,56 and 110 may be closed and valves 60 and 74 opened. This causes the suction force from the pump 30 to be transferred to the holding tank 104. From the holding tank 104 the suction draws the liquid 18 and compressant 26 and any filtrate from the reservoir 12 and separator tank 14 through suction line 16 into the holding tank 104.

It is far easier to clean only the holding tank 104 than the reservoir 12 and separator tank 14 also. This reduces the haphazard depositing of wastes after cleaning and greatly increases safety for an operator and any onlookers if working with toxic materials such as caustic soda or asbestos.

The holding tank 104 may have provided therein a mesh filter and a ball-float valve at the point where the suction line 16 exits therefrom.

With reference to the cooling apparatus 50 of Figure 2 there is an added feature to the cleaning of the separator 14 and reservoir 12. The referred suction from the pump 30 through the suction line 16 causes the compressant 26 and any filtrate therein to be drawn through the flushing line 72 and discharged through the plurality of apertures 76 to wash the walls of the reservoir 12. The fluid 18 has been drawn through the suction line 16 prior thereto and the

compressant 26 is in turn sucked through the suction line 16.

It is envisaged that a spray jet may be provided in the suction line 16 to dampen any incoming contaminants and thereby increase the efficiency of contaminant removal by the fluid 18.

The cooling apparatus of the present invention eliminates the need for an external heat exchange by providing the reservoir 12 and liquid 18 therein to draw heat from the compressant 26. This provides a pump able to operate for longer periods at high efficiency while allowing a compact system without the need for an external heat exchange.

It is further envisaged that the radiator 62 or similar heat transfer device may be positioned at a point other than the discharge line 32.The suction cleaning system 100 provides a truck or trailer mountable cleaning system that is able to run for longer periods at a greater efficiency and efficacy due to its cooling of pump water, is space economic and at least partially self cleaning.

Modifications and variations such as would be apparent to a skilled addressee are deemed within the scope of the present invention.

CLAIMS

1. A cooling apparatus for recirculating vacuum pump compressant characterised by a liquid reservoir located upstream of an air-suction pump in a suction line and a separator tank containing a volume of compressant located downstream of the air suction pump in a discharge line, the separator tank having at least part thereof in contact with the liquid reservoir and a recirculation line extending from the separator tank to the pump to recirculate compressant whereby heat from the separator tank may be transferred to the liquid reservoir.

2. A cooling apparatus according to claim 1, characterised in that the suction line feeds into the liquid reservoir in such a manner that incoming air and any matter contained therein disturbs the liquid therein, whereby more heat may be transferred to the liquid and a proportion of any particulate matter may be removed thereby.

3. A cooling apparatus according to claim 1, characterised in that the suction line feeds into the liquid reservoir in such a manner that incoming air and any matter contained therein generates a stream of bubbles in the liquid therein, whereby more heat may be transferred to the liquid and a proportion of any particulate matter may be removed by the liquid.

4. A cooling apparatus according to any one of claims 1 to 3, characterised in that an additional pump is provided in the recirculation line to aid in recirculation of the compressant.

5. A cooling apparatus according to any one of the

preceding claims, characterised in that the separator tank is mounted in contact with the reservoir such that at least part thereof is in direct contact with the liquid therein.

6. A cooling apparatus according to any one of the preceding claims, characterised in that the separator tank is provided with an extension thereto, the extension having at least part thereof in contact with the reservoir.

7. A cooling apparatus according to claim 6, characterised by the part of the extension to the separator tank in contact with the reservoir being formed into a number of coils at least partly in direct contact with the liquid in the reservoir.

8. A cooling apparatus according to any one of claims 5 to 7, characterised in that the part of the separator tank in direct contact with the liquid does so at a position in which the liquid is disturbed by incoming air and any matter contained therein.

9. A cooling apparatus according to any one of the preceding claims, characterised in that the suction line from the reservoir to the pump extends from the reservoir at a point above a normal liquid level therein.

10. A cooling apparatus according to claim 9, characterised in that the point in the reservoir from which the suction line extends to the pump has provided thereat a ball-float valve to prevent liquid passing into the suction line.

11. A cooling apparatus according to any one of the preceding claims, characterised in that a non-return valve is provided in the suction line between the pump and the

reservoir.

12. A cooling apparatus according to any one of the preceding claims, characterised in that a radiator is positioned in one or both of the discharge line between the pump and separator and the recirculation or feed line.

13. A suction cleaning system characterised by an air-suction pump, a liquid reservoir located in a suction line upstream of the pump, a coarse filter or settling tank further upstream in the suction line, a separator tank containing a volume of compressant located in a discharge line downstream of the pump and being at least partially in contact with the liquid reservoir, and a recirculation line extending from the separator tank to the pump to recirculate compressant, whereby heat may be transferred from the separator tank to the liquid reservoir.

14. A suction cleaning system characterised in that it incorporates a cooling apparatus as described in any one of claims 1 to 12 in addition to having a coarse filter or a settling tank provided upstream of the reservoir in a suction line.

15. A suction cleaning apparatus according to claim 14, characterised in that a suction inlet line is provided upstream of the settling tank and has a valve located therein.

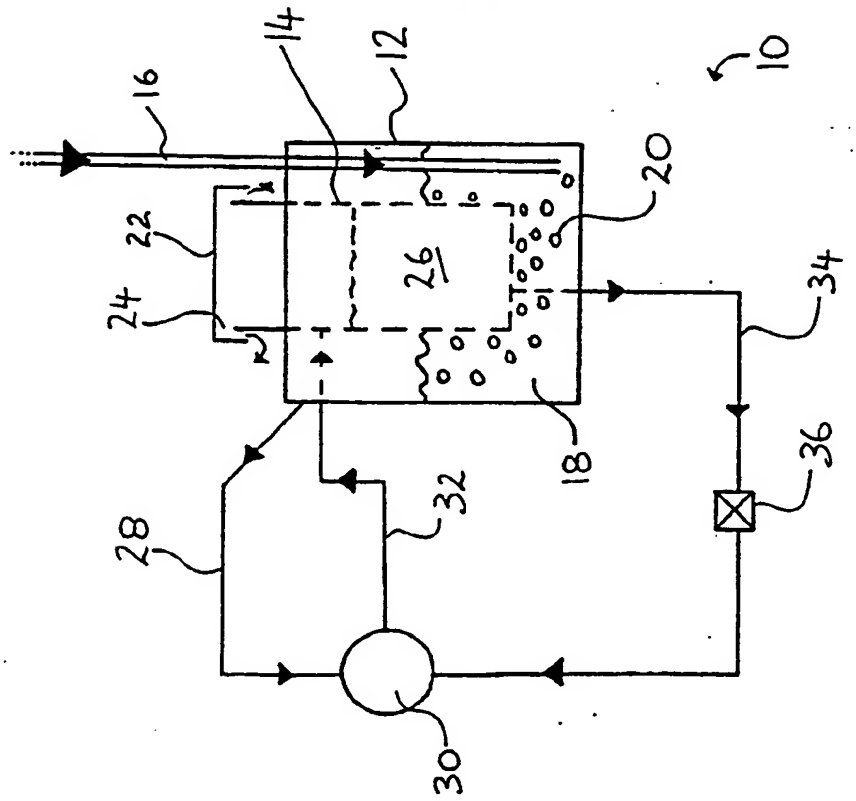
16. A suction cleaning system according to any one of claims 14 or 15, characterised in that a bypass line having a valve therein is located so as to connect the suction line between a further valve located therein and the pump and the settling tank.

17. A suction cleaning system according to any one of claims 14 to 16, characterised in that a valve is provided at or near a base of the separator tank allowing communication between the separator tank and the reservoir.

18. A suction cleaning system characterised in that it incorporates a cooling apparatus as described in any one of claims 6 to 8 in addition to having a coarse filter or a settling tank provided upstream of the reservoir in a suction line, wherein a flushing line is provided having a valve therein between a base of the separator tank and the reservoir.

19. A method of cleaning a suction cleaning system according to claim 17 or 18, characterised in that upon closing the valves in the suction line between the pump and the reservoir and in the suction inlet line and opening the valves in the bypass line and the valve in the separator tank or flushing line, then the suction from the pump is referred through the bypass line to the settling tank wherefrom the suction is referred to the reservoir from which the liquid and any contaminants is sucked into the settling tank, the suction then being referred to the separator tank from which the compressant is sucked into the reservoir and in turn to the settling tank which may then be cleaned.

FIGURE 1



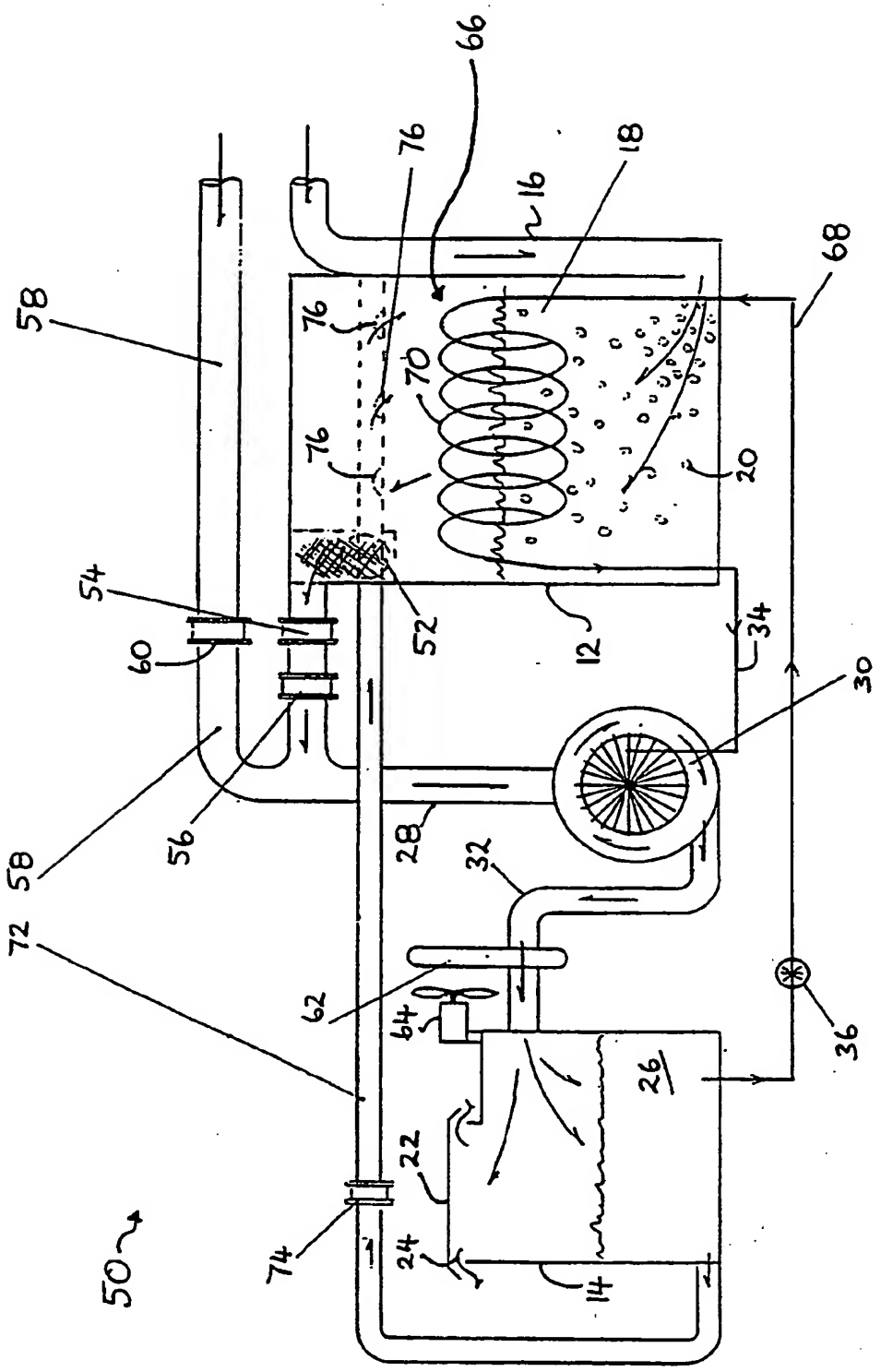


FIGURE 2

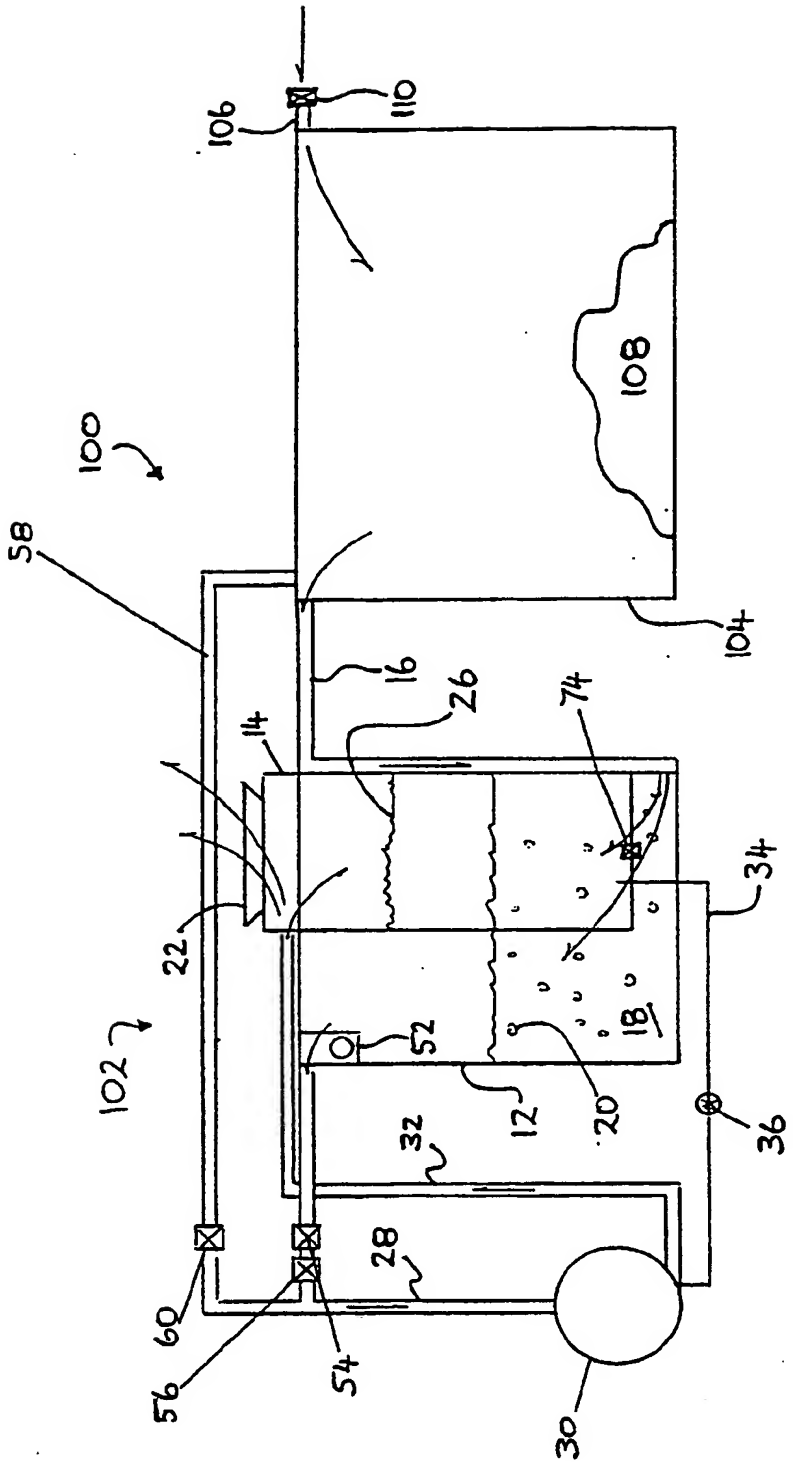

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FIGURE 3

INTERNATIONAL SEARCH REPORT

International application No.
PCT/AU92/00326

A. CLASSIFICATION OF SUBJECT MATTER
Int. Cl[5]. F01C 7/00, F04C 7/00, 19/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC F01C 7/00, F04C 7/00, 19/00, 29/04

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
AU:IPC as above, Australian Classification 67.7

Electronic data base consulted during the international search (name of data base, and where practicable, search terms used)
DERWENT

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate of the relevant passages	Relevant to Claim N .
X	DE,A, 3204784 (SIEMENS AG) 25 August 1983 (25.08.83) page 3, line 31 - page 5, line 12	1-2, 4, 9-12
Y	DE,A, 4036516 (KKW KULMBACHER KLIMAGERATE-WERK GmbH) 23 May 1991 (23.05.92) drawing figure	1, 4, 12
Y	DE,A, 908658 (MASCHINE FABRIK BURCKHARDT A.G) 8 April 1954 (08.04.54) figure 2	1, 4, 12

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
19 August 1992 (19.08.92)	1 Sept 1992 (01. 09. 92)
Name and mailing address of the ISA/AU AUSTRALIAN PATENT OFFICE PO BOX 200 WODEN ACT 2606 AUSTRALIA Facsimil No. 06 2811841	Authorized officer C.M. WYATT T lephone No. (06) 2832538

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication, where appropriate f the relevant passages	Relevant to Claim No.
Y	Derwent Abstract Accession No. 91-034802/05, Class Q56, SU,A, 1566085 (MAKSIMOV) 23 May 1990 (23.05.90)	1, 4, 12
Y	US,A, 4359313 (BERNARD) 16 November 1982 (16.11.82) column 1, line 58 - column 2, line 60	1, 4, 12

ANNEX TO THE INTERNATIONAL SEARCH REPORT ON INTERNATIONAL APPLICATION NO. PCT/AU 92/00326

This Annex lists the known "A" publication level patent family members relating to the patent documents cited in the above-mentioned international search report. The Australian Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent Document Cited in Search Report	Patent Family Member		
DE 3204784	US 4484457	EP 88226	
DE 4036516	EP 437637		
US 4359313	AU 536869		

END OF ANNEX